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Study on Flow Field Uniformity at the Outlet of Denitrtion Reactor and Optimization of Diversion Structure

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Abstract. Due to the problem of reforming the reactor, the original supporting column at the outlet of the equipment has a negative influence on the uniformity of the flue gas. In this paper, CFD simulation technology is used to simulate the smoke movement at the outlet of the denitration reactor, using the standard *k-ε* turbulence model and mass transport model, the influence law of the column on the smoke is obtained, and the wedge guide plate is designed. The flow of flue gas is guided through the shape of the wedge splitters to improve the uniformity of the flue gas and eliminate the impact phenomenon of the economizer.

Introduction

In recent years, the problem of air pollution is becoming more and more serious. We have paid a huge environmental price for the economic development. So far, Our country has been the main source of energy by burning coal, nitrogen oxides pollution is particularly serious in industrial waste gas. Based on this situation, denitration technology has been widely used in China. Compared with other denitration technologies, SCR denitration method has many advantages, is the most widely used method of denitrification[1].

At present, the structural design of SCR denitration tower equipment used by many enterprises in China is copied abroad [2]. At the outlet of the SCR denitration equipment, there is an uneven distribution of the support column, which has a negative impact on the flow of flue gas. The deflector is usually a straight guide plate and an arc deflector plate, or a combination of the two, but it is clear that the shape of the deflector is unable to solve the adverse effects of columns. In this paper, a wedge guide plate is designed for the special case of the outlet of a 390 thousand m^3/h SCR denitration tower, so that the movement of smoke at the outlet of the equipment is improved.

The Determination of Numerical Simulation Model and the Object of Study

The Standard *k-ε* two equation mode. The SCR denitration reactor system is three dimensional turbulent flow, so the turbulence model using standard *k-ε* turbulence model.The reynolds stress can be expressed as follows[3]

$$-\rho u_i u_j = u_t\left(\frac{\partial u_i}{\partial u_j}+\frac{\partial u_j}{\partial u_i}\right)-\frac{2}{3}\rho k\delta_{ij} \tag{1}$$

$$u_t = \rho C_u \frac{k^2}{\varepsilon} \tag{2}$$

Here, u_t is turbulent viscosity, k is turbulent kinetic energy term, ε is turbulent energy dissipation rate.

The actual running situation of denitration equipment is complicated and changeable. In order to ensure the accuracy of numerical simulation, and simplify the calculation we make a few assumptions: (1) The solid particles in the gas are not considered, they are regarded as incompressible ideal gases.(2) SCR denitration equipment system is huge, we only intercept the denitration equipment export part of the simulation, and set the flue gas into the device is uniform.(3) The wedge splitters is formed by bending, the thickness of the device is relatively small, estimated negligible.(4) In order to simplify the calculation model, we lose sight of the internal parts that have little effect on gas flow[4].

The Outlet Structure and Smoke Movement of the Denitration Reactor. The export structure of the 390,000 m^3 / h SCR denitrification tower studied in this paper is shown in Figure 1. From the diagram we can see that there are five non-uniformly distributed support posts at the exit. In the process of flue gas entering the boiler through the column, due to the role of the column obstruction, a serious separation of the flue gas, resulting in uneven smoke to reach the boiler surface of the economizer, At the same time due to the sharp increase in cross-sectional area, the sudden increase in the speed of flue gas, resulting in the particles in the flue gas for the impact of the surface of the economizer. According to the actual situation of the project, in Figure 1, there is a serious flue gas concentration and wear in the shaded area, the blank area of the boiler inlet is a region free of gas or less gas, On the left side of column 2 to 4, there was a large area of no gas.

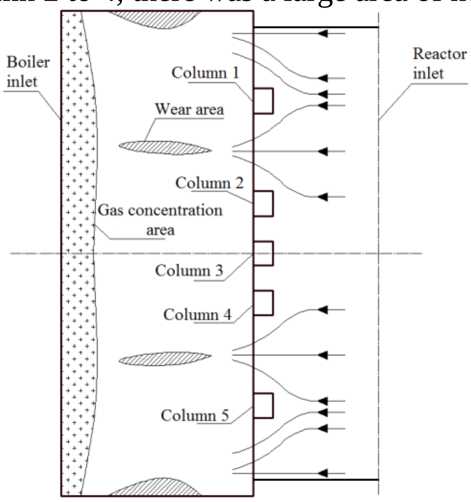

Figure 1. Demonstration of the structure of SCR denitrification reactor

Numerical Simulation of SCR Denitrification Reactor and Optimization of Splitters

Optimization Evaluation Criteria. In order to judge the degree of uniformity of gas flow, the concept of deviation coefficient is put forward. In this paper, it is worth to judge the gas uniformity by the velocity deviation of the section above 200mm. That is, the ratio of the standard deviation of the velocity and the average velocity in the section, and the formula for calculating the velocity deviation value CV is as follows[5]:

$$C_V = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{V_i - \bar{V}}{\bar{V}}\right)} \times 100\% \qquad (3)$$

Here, V_i is the velocity value for each measurement point, $\bar{V}$ is the average velocity on the measuring surface.

Firstly, the flow field of the outlet of the denitration tower which has no guide plate was analyzed, as shown in Figure 2. The velocity deviation coefficient is 95.8%, which is a high deviation value, at this point the highest gas velocity is 38.5m/s. It can be seen that the flue gas is concentrated on the left side of the boiler inlet, most of them have no smoke .the smoke wear area appears on both sides of the column. This is consistent with the actual situation (Figure 1), We need to develop a guide plate to guide the flue gas distribution more uniform. We can also find out from the nephogram, the vertical distribution of flue gas is mainly affected by the support column, however, in the part near the exit, the distribution of smoke is basically zero due to the high speed of flue gas, this kind of lateral distribution problem must be solved by the optimization of the straight guide plate.

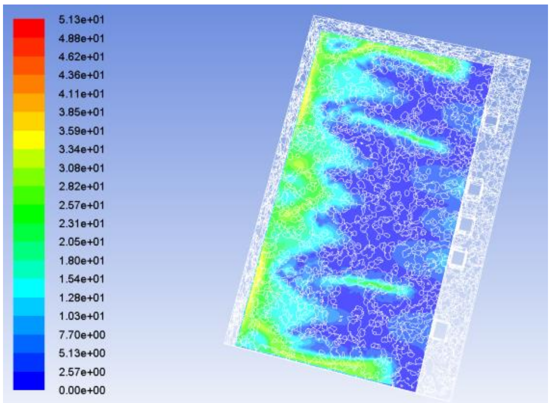

Figure 2.Flow field analysis of unoptimized outlet of the denitration reactor

Optimization of splitters. From the above analysis we can know that there is a problem that the distribution of gas in the longitudinal and transverse directions of the denitrification reactor is uneven. We designed a combination of direct and wedge splitter optimization program, the specific program shown in Figure 3 and Figure 4.It should be noted that the wedge splitter 2 and wedge splitter 4 in Fig. 3 are not symmetrical in order to allow the gas to converge in the middle to compensate for the lack of central gas. The wedge splitter uses a streamlined design to reduce the adverse effects on the gas. The direct splitter in Figure 4 regulates the lateral distribution of the gas. As can be seen from the diagram, the gas can reach the exit of the denitrification reactor due to the effect of the straight splitter.

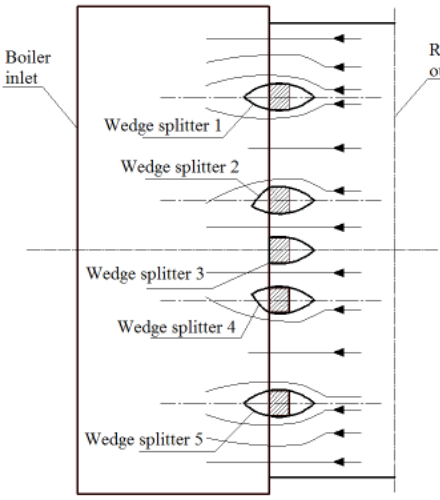

Figure 3.Wedge splitters installation scheme diagram

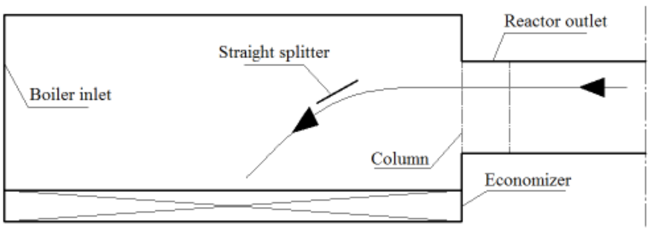

Figure 4. Straight splitter installation diagram

We have carried out a numerical simulation of the denitrification tower outlet with the splitter. The results are shown in Figure 5.The speed deviation coefficient is 68.1% and the maximum speed is 24.5m/s, which are both significantly lower than that before the optimization. The concentration of wear area disapper. The area of the gas-free area is also significantly reduced. The gas in the horizontal and vertical distribution than before the optimization has been significantly improved. The optimization scheme has basically solved the problem of uneven gas distribution and flow rate at the outlet of the denitrification tower, which meets the technical requirements of engineering application.

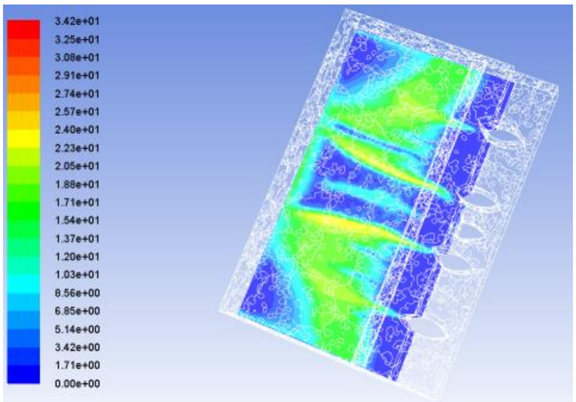

Figure. 5 Analysis of the flow field in the outlet with splitters

Conclusions

According to the numerical simulation of denitration tower, We found the influence of the support column on the gas flow, and divided the inhomogeneous distribution into two parts, It is only possible to solve the problem of uneven distribution of gas with the usual direct guide plate, which cannot solve the problem of excessive gas velocity and uneven longitudinal distribution, In this paper, the author puts forward the design of wedge guide plate, which can reduce the adverse effect of the support column on the longitudinal distribution of gas, and eliminate the phenomenon of the increase of the extrusion speed, Through the combination of the wedge guide plate and the direct flow guide plate, the flow field distribution of the gas can meet the requirements of the technical specifications.

Acknowledgements

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